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Reflection-based 90° sharp turn for InP membrane waveguide circuits

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Abstract: In this work we present the design of a sharp waveguide bend for an InP photonic membrane platform. The reflection-based bend has an effective radius of only 0.96 μm. Low loss and broad band operation are verified.

Waveguide bends are common but very critical building blocks in photonic integrated circuits (PICs) [1]. They alter light propagation directions and therefore bridge functional devices on the chip. The bends have to be both compact and low loss for maximized circuit integration density and performance. This is especially important in applications such as on-chip optical interconnects [2], with very strict space and power consumption limits.

Indium phosphide (InP) membrane technology [3] is a promising candidate for the next-generation PICs. Realizing InP-based photonic circuits in a thin membrane brings the advantage of very high integration density. The optical confinement in membrane waveguides can be greatly enhanced by the low-index optical buffer layer between the membrane and the substrate. The InP membrane waveguide cross-section is depicted in Fig. 1(a).

In silicon-on-insulator (SOI) membranes, low-loss waveguide bending radius as small as 1 μm have been demonstrated [4]. For InP membranes the situation is quite different due to the relatively lower index contrast of InP membrane (InP/SiO_2: 3.16/1.45) as compared to the silicon membrane (Si/SiO_2: 3.47/1.45). This leads to higher radiative loss in the bends, higher sensitivity to sidewall roughness and larger minimum bending radius as compared to the silicon membrane counterparts.

We propose a novel waveguide bend design using the principle of total internal reflection (TIR). This concept utilizes a 45° facet for sharp turning of the light, and an extended square region for loss reduction [5]. Thanks to the high-confinement of light

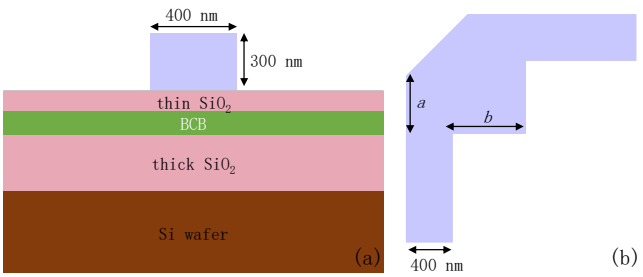

Fig. 70. (a) Cross-section of InP membrane waveguide. (b) Schematic diagram of the proposed sharp bend.

in the membrane layer, the TIR efficiency can be very high to ensure low loss of the structure. The schematic design of the sharp bend is shown in Fig. 1(b).

The optimization of this structure is performed with a 3D finite difference time domain (FDTD) algorithm. It is found that when parameters *a* and *b* are 515 and 760 nm respectively, the bending loss is as low as 0.13 dB at 1550 nm wavelength. Taking into account the half-width of the input waveguide, the effective bending radius is only 0.96 μm. The electric field distribution inside the optimized structure is shown in Fig. 2(a). As can be seen the light propagation inside the device is nearly lossless. The spectral behavious of the sharp bend is given in Fig. 2(b). A broadband operation is obtained with only 0.07 dB loss variation over a 100 nm wavelength range.

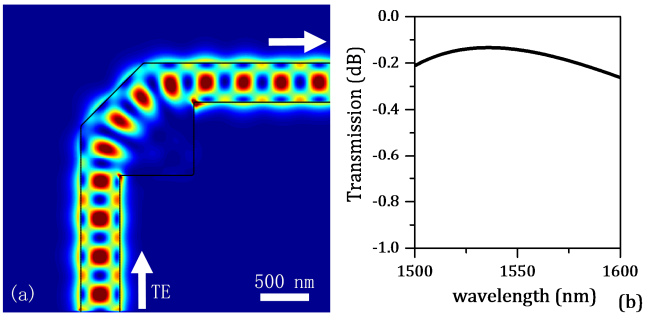

Fig. 71. (a) Calculated electric field distribution for TE polarization. (b) Bending loss as a function of wavelength.

In conclusion, we have proposed a novel sharp waveguide bend structure, perfectly suitable for the InP photonic membrane circuits. The design has advantages of low loss, broadband operation and ease of fabrication. This bend will be used as a standard building block in our InP membrane PIC platform.

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